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INTRODUCTION

ACL Injuries in Professional Football

Football is one of the most widely played sports globally, with over 260 million participants worldwide while approximately 130,000 are professional (Herrero, Salinero and Del Coso, 2014). Football is also a sport with a high injury risk, with an overall injury rate of 6.6 injuries per 1,000 player hours (Ekstrand *et al*, 2021). One of the most severe injuries is an anterior cruciate ligament (ACL) rupture, which is particularly concerning as it may lead to osteoarthritis within 15–20 years (Volpi, 2006). Additionally, in professional football, 60% of players who sustained an ACL rupture were competing at the highest level five years post-injury (Della Villa *et al*, 2021). Moreover, ACL injuries in football result in an average injury burden of 29.8 days per 1000 hours of exposure (Tabben *et al*, 2022). In fact, ACL injuries constitute 53% of all knee injuries in football, emphasising the prevalence of this injury within the sport (Jurkonis, 2018), the incidence rate of ACL injuries was reported as 2.0% in female football players, compared to a higher rate of 3.5% in male players (Montalvo, 2019). However, ACL injuries are not an injury with a high incidence, with an average of 0.43–0.60 injuries per team per season in football professional team (Waldén *et al*, 2016).

Return to play (RTP) criteria are crucial in professional football due to the risk of re-injury following RTP. With high injury rates in the sport, a well-structured RTP process is essential to safeguard player health and optimise their performance. Recent research emphasises that RTP decisions usually follow a process utilising clinical, functional, and psychological

evaluations, with many teams using a collaborative decision-making approach involving various departments within the sporting organisation (Dunlop *et al*, 2020). The significance of injury rehabilitation programs is highlighted by numerous studies emphasising the difficulties players encounter in regaining their pre-injury performance levels. Despite an 80% return-to-play rate among elite soccer players following ACL reconstruction (ACLR), a significant performance decline often persists for at least two seasons post-injury, emphasising the vital role of rehabilitation in regaining players capabilities (Forsythe *et al*, 2021).

This essay will analyse the evidence for RTP criteria and injury reduction strategies, specifically focusing on ACL injuries in football. It will examine RTP decisions, including clinical, functional, and psychological assessments, while examining how they affect player outcomes and performance. Additionally, the essay will evaluate the effectiveness of various injury prevention strategies, such as strength and conditioning (S&C) programs and screening protocols, to reduce the risk of ACL injuries.

COMMON CAUSES OF ACL INJURIES IN FOOTBALL

Studies have explored how and why ACL injuries happen in football, offering important insights into this issue. Research highlights key risk factors, such as a history of ACL injuries or other knee-related injuries (Szymiski *et al*, 2022). Furthermore, a study on professional male football players identified three primary mechanisms for ACL injuries, which were, knee joint movements during specific game scenarios such as pressing and tackling, recovering balance after kicking, and the act of being tackled (Della Villa, 2020). With regards to contact ACL injuries, one study analysing 55 videos of ACL injuries in football players found that a significant majority occurred during defensive actions, with 73% of the injuries happening in scenarios where the opposing team were in possession. Tackling was the most common action linked to these injuries, accounting for 51% of cases, with contact mechanisms contributing to 56%, highlighting the risk associated with defensive actions (Brophy, 2015). Sudden directional changes, often known as cutting manoeuvres, are also recognised as major factors contributing to non-contact ACL injuries (Tarmah, Rahnema, and Khayyambashi, 2010). It has also been shown that inadequate neuromuscular control and muscle imbalances are key contributing factors for ACL injuries. Players with an elevated risk for ACL injuries often demonstrate reduced knee flexion angles during athletic

movements, highlighting a connection between neuromuscular control deficits and increased vulnerability to injury (Papoutsidakis, 2011). Additionally, a review of injury prevention programs highlighted that successful interventions frequently focus on enhancing neuromuscular control and correcting muscle imbalances, which in turn can reduce the risk of non-contact ACL injuries (Mattu *et al*, 2022). Further to this, research suggests a link between knee valgus and an increased risk of ACL injuries in football players. A study specifically found that dynamic knee valgus is associated with a heightened risk of ACL injuries, especially among young male players (García-Luna *et al*, 2020). In conclusion, ACL injuries in football arise from a combination of contact and non-contact mechanisms, with defensive actions, tackling, and cutting manoeuvres being key contributors.

REHABILITATION AND RETURN TO PLAY FROM ACL RECONSTRUCTION

Muscular Endurance, Strength and Power

Individualised, well managed, progressive rehabilitation is critical for a footballer to return to play (RTP) and minimise the risk of injury recurrence. The primary objective of the rehabilitation process is to minimise the severity of the injury, restore impaired function, and prevent or resolve any associated disabilities (Frontera, 2008). Players who undergo rehabilitation programs demonstrate significant improvements in muscle strength and aerobic fitness, highlighting the effectiveness of tailored programs in achieving full functional recovery and ensuring a safe RTP (Della Villa *et al*, 2012).

Restoring joint range of motion is a key focus in the initial phase of injury rehabilitation (Konrad *et al*, 2021). Strengthening exercises are often introduced alongside or shortly after ROM exercises, as improving joint mobility without enhancing strength may increase the risk of further injury. Once adequate ROM has been achieved, muscular endurance exercises are introduced in the form of isometric exercises. Isometric exercises involve muscle contraction without any change in muscle length or joint angle, allowing the muscle to generate force while limiting further stress to the injured tissue (Oranchuk *et al*, 2019). While evidence of duration prescription is limited, research does claim that short-duration isometric contractions can be as effective as longer ones for pain relief when the total time under tension is matched,

which offers therapists flexibility in prescribing isometric exercises, particularly for players who struggle holding contractions for extended periods (Pearson *et al*, 2020). Muscular endurance plays a crucial role in ACL rehabilitation by allowing the muscles around the knee, especially the quadriceps and hamstrings, to sustain prolonged activity and provide stability during functional movements.

Following this phase, muscular strength becomes the focus of rehabilitation, when if the player meets progression criteria such as tolerance to previous interventions, adequate quadriceps and hamstring strength, reflected by strength symmetry greater than 90% relative to the uninjured limb (Paterno, 2017), concentric, followed by eccentric open and closed chain exercises can be introduced. Criteria to progress to this phase are walking with no limp, bilateral and single squat to 90 degrees, bilateral landing control from sub-maximal jump, 30 cm bilateral drop jump, single leg drop jump, 90 degree cut manoeuvre and 45-degree reactive change of direction (Buckthorpe, Tamisari and Della Villa, 2020).

A structured strength training rehabilitation program is crucial for effective rehabilitation, as it helps restore muscle strength, improves knee function, minimises the risk of re-injury, and ensures a safe return to athletic performance (Bregenhof *et al*, 2023). This phase utilises increased load, with intensities reaching 70-80% 1RM (Richens and Cleather, 2014), however research is unclear on the optimal prescriptions. Exercises such as various forms of Squats, Step Ups and Leg Extensions to strengthen the Quadriceps, Leg Curls and Romanian Deadlifts to strengthen the Hamstrings, while the importance of strengthening the Gastrocnemius, Soleus, and the musculature around the hips should be considered. Power training is a vital component of performance in rehabilitation in football, emphasising the development of maximal muscular power. Muscular power is the capacity to produce force quickly, integrating strength and speed to execute explosive actions (Kraemer and Looney, 2012). Training with loads around $41.7\% \pm 5.8\%$ of 1RM and performing 4 to 9 explosive repetitions per set is highly effective for enhancing power performance (Sarabia *et al*, 2017). Power training is essential in ACL rehabilitation for footballers, as it improves their capacity to execute explosive actions like sprinting, jumping, and changing direction, all of which are fundamental to return to play and as an injury reduction strategy. While much of the evidence supports these modalities in terms of rehabilitation and injury risk reduction, further research may consider more specific load ranges, as well as time and repetition quantities and volume.

Speed, Acceleration, Deceleration and Plyometric training

When the above qualities have been achieved, and the player has met progression criteria such as no episodes of instability, maintain quadriceps strength, single leg squat with proper form through at least 60 degree of knee flexion and vertical jump with good control, the player can progress to Speed, Acceleration, Deceleration and Plyometric training. Numerous studies detail the role of these qualities in football performance and rehabilitation. A systematic review of youth football players found that plyometric training enhances speed and agility and recommended its integration into structured programs to optimise performance and reduce injury risk (Bedoya, Miltenberger and Lopez, 2015). Thus, incorporating plyometric programs into rehabilitation helps reduce re-injury risk by improving neuromuscular control and movement efficiency, facilitating a safer return to play. Furthermore, acceleration and deceleration training are essential aspects of ACL rehabilitation for footballers, as these movements are critical for meeting the demands of the sport. This form of training improves a player's efficiency in starting, stopping, and changing direction, which is crucial for performance, while also helping reduce injury risk by promoting safe speed reduction (Wolfe *et al*, 2023). However, it is important to emphasise that acceleration and deceleration training focuses not only on boosting performance but also on improving movement mechanics to reduce the risk of injury, as inefficient deceleration techniques can place undue stress on the ACL. Additionally, Change of Direction (COD) interventions are commonly used as performance improvement drills, as well as during the latter stages of ACL rehabilitation programs. COD training improves neuromuscular control, allowing athletes to perform movements with better precision and stability, which is crucial for preserving joint integrity and preventing injuries (Dos Santos *et al*, 2019). Moreover, as football involves frequent and rapid changes in direction, there is a higher risk of ACL injuries. COD training in rehabilitation targets the specific movement patterns and biomechanical factors that contribute to injury risk in footballers, making the process more relevant and effective (Marques *et al*, 2020). There is strong evidence supporting the incorporation of Speed, Acceleration, Deceleration, and Plyometric training in ACL rehabilitation for footballers, with numerous studies demonstrating their positive impact on performance improvement and injury risk reduction.

Return to sprinting

Sprinting is a high-intensity movement that involves quick acceleration, deceleration, and directional changes, which are essential to football and replicate the physical stress that the knee undergoes during a game. As sprinting is a fundamental aspect of football, then it forms an important part of injury prevention and rehabilitation. The rehabilitation process should include criteria-based progressions for sprinting to ensure players rebuild the required strength before returning to play. This aligns with recent guidelines highlighting the significance of extended RTP timelines and the use of open kinetic chain exercises to support recovery (Brinlee *et al*, 2022). The criteria to progress from this stage is at Stage 1 to complete a four-week walk-to-jog program for 30 minutes, quadriceps and hamstring strength reaching at least 70% of the uninvolved side, hop test performance at a minimum of 70% of the uninvolved side, with no pain or effusion present. Stage 2 is completion of Stage 1, achieving 80-85% or higher in all strength and functional tests, with full passive flexion restored, while Stage 3 is completion of Stage 2, all strength and functional testing 90% or better, no effusion or pain (Lorenz and Domzalski, 2020). While this approach offers a foundation, its limitations should be recognised. The program primarily emphasises linear sprinting and lacks integration of multidirectional or sport-specific movements, which are essential for football performance and ACL injury prevention and rehabilitation.

Screening and injury reduction strategies and models of prevention

Evaluating the risk of ACL injuries in football players involves screening tools aimed at identifying risk factors. Assessments like the Star Excursion Balance Test (SEBT) are used to evaluate an athlete's balance and postural stability. An anterior reach difference greater than 4 cm or a composite reach distance less than 4% of limb length on the SEBT may indicate increased injury risk (Dallinga, Benjaminse, and Lemmink, 2012). Additionally, tools like the Landing Error Scoring System (LESS) analyse an athlete's jump-landing mechanics to identify incorrect techniques that may predispose them to ACL injuries. The LESS is a simple and reliable tool that clinicians can use to identify individuals at risk for lower extremity injuries, however, a limitation of this tool is that it requires video cameras and cannot be assessed in real time (Padua *et al*, 2011). Furthermore, Functional Movement Screen (FMS) evaluates movement patterns to detect imbalances or limitations that may screen for injury risk and is recommended in football. An FMS score of 14 or below

significantly increases injury risk, with an 11-fold higher chance of injury and a 51% likelihood of a serious injury during one competitive season (Chorba *et al*, 2010). However, research suggests that FMS may have limited ability to predict injuries. A study found that it only slightly outperformed random chance in identifying individuals at risk for musculoskeletal injuries (Dorrel *et al*, 2018). Moreover, strength and imbalance testing of key muscle groups such as the quadriceps and hamstrings are important to assess ACL injury risk. Isokinetic testing is widely used, particularly in the professional football environment. A study examining isokinetic muscle strength in elite football players found significant variability in strength measurements over time, regardless of injury status. However, the study found a weak correlation between isokinetic eccentric strength and strength measured by the Nordic hamstring exercise, highlighting the limited predictive value of isokinetic testing (Van Dyk, Witvrouw and Bahr, 2018).

Injury prevention depends on comprehensive models that consider the multiple factors contributing to injuries. One such model is the Translating Research into Injury Prevention Practice (TRIPP) Framework. TRIPP focuses on applying research findings to practical injury prevention through a systematic approach which includes identifying injury problems, understanding their causes, implementing prevention strategies, and evaluating their effectiveness in reducing injury rates (Finch, 2006). The Team-Sport Injury Prevention (TIP) Cycle is another model of injury prevention, *et al*, which is designed for team sports, involves assessing injury risk factors, developing interventions, implementing them within the team, and adjusting the programs to ensure effectiveness. Although the TIP framework highlights the need to apply research to practical injury prevention, it lacks detailed guidance on how to develop evidence-based programs in real world situations (Padua *et al*, 2014). Finally, the Acute, Chronic Workload Ratio Model is a model that monitors acute and chronic training loads to prevent injuries by analysing short-term and long-term training intensities. One review highlighted that variations in workload variables and ratios can impact injury risk outcomes (Maupin *et al*, 2020). However, training load adjustments suggest that static models like the ACWR may not fully reflect the dynamic nature of injury risk (Rebelo *et al*, 2023). Furthermore, warm-up interventions such as the FIFA 11+ are effective for football teams ranging from community to elite levels (Olivares-Jabalera *et al*, 2021). Although screening tools and injury models provide useful information on injury risk, their limitations, such as difficulty with real-time use, and not fully capturing training dynamics, suggest the need for more flexible injury prevention methods.

RETURN TO PLAY CRITERIA

The 11 to Perf Score is used to evaluate an athlete's preparedness to RTP after an ACL injury. A score of 21 or higher out of 30 is generally considered the minimum requirement for a footballer to safely RTP after an ACL injury. The 11 to Perf Score is based on five key criteria, each rated on a scale from 0 to 3, with higher scores reflecting greater readiness to return to play. These include ACL-RSI, measuring psychological readiness; 30/15 VO₂ max test for aerobic fitness, RSA Fatigue Index to assess fatigue resistance and RSA Index for sprint performance efficiency, and landing metrics (Disegni *et al*, 2024). However, the lack of a standardised rehabilitation and RTP assessment approach may limit the effectiveness and applicability of specific scoring systems, such as the 11 to Perf Score.

CONCLUSION

Football specific rehabilitation after ACL injury lacks standardisation, even though numerous studies have evaluated protocols for RTP and preventing further injuries. Although tools like the 11 to Perf Score provide insights into a player's readiness, their effectiveness is limited by the lack of an accepted approach. Future research should establish rehabilitation protocols, improve RTP testing, and investigate personalised approaches to aid recovery and minimise the risk of re-injury.

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